Prompt photon production in p–A collisions and gluon shadowing

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Shadowing

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Leading twist modification of per-nucleon parton densities

$$u_p(x, Q^2) \quad \longrightarrow \quad u_A(x, Q^2),$$
$$G_p(x, Q^2) \quad \longrightarrow \quad G_A(x, Q^2), \ldots$$

also described by ratios, e.g.

$$R_G^{(A)}(x, Q^2) = G_A(x, Q^2)/G_p(x, Q^2)$$

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worth knowing in the shadowing region, i.e. $x < 10^{-1}$

Current knowledge

Reviews: Arneodo, M, Phys Rep 240, 301 (1994) ; Armesto, N, J Phys G 32, R367 (2006)

Extracted from deep inelastic scattering and Drell-Yan data

Several global fits (with DGLAP evolution): Eskola *et al* (EKS),...

We used 1st **NLO** analysis from de Florian and Sassot (nDS)

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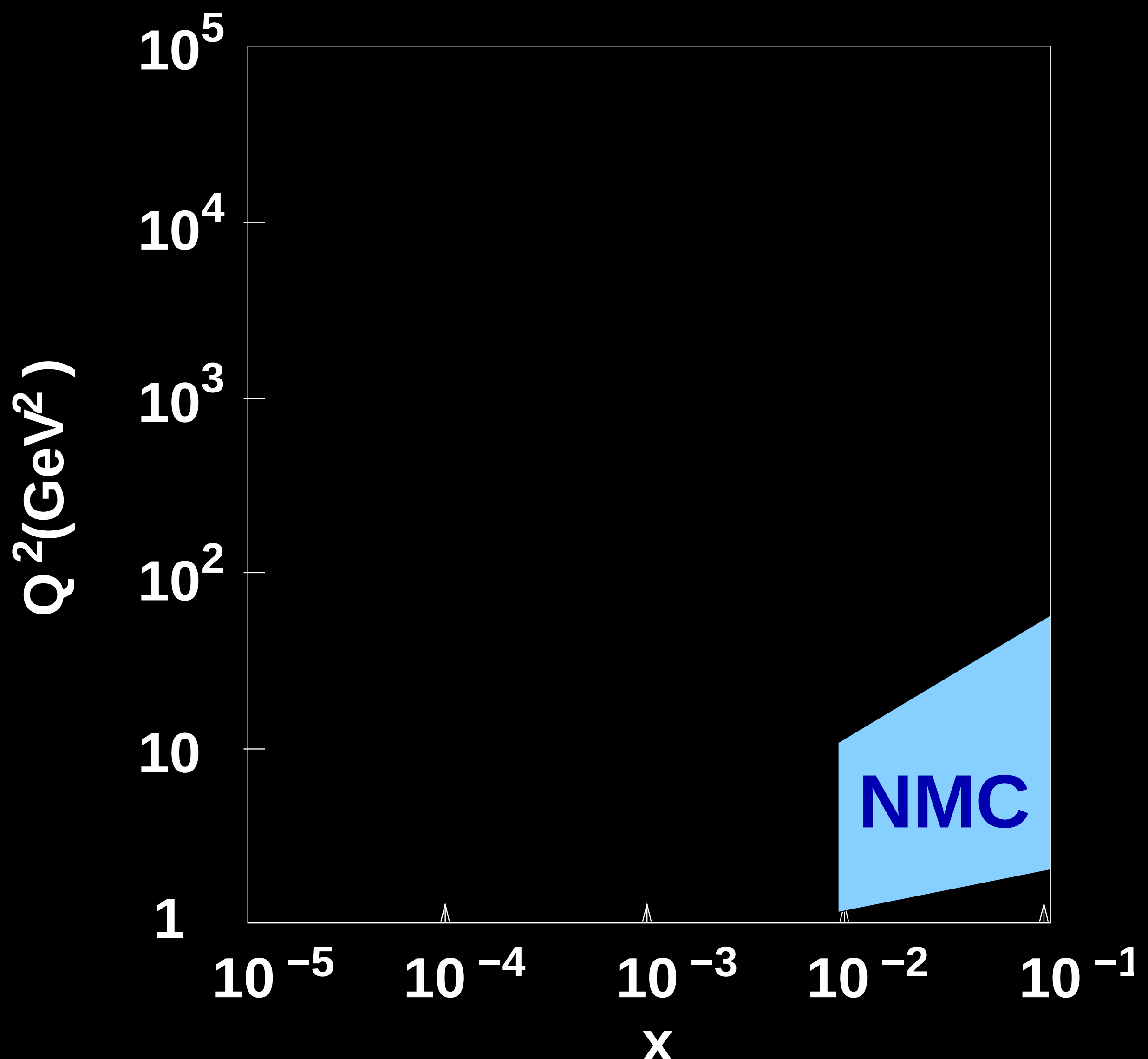
$\Rightarrow$ **gluon practically unconstrained**

$x - Q^2$ map



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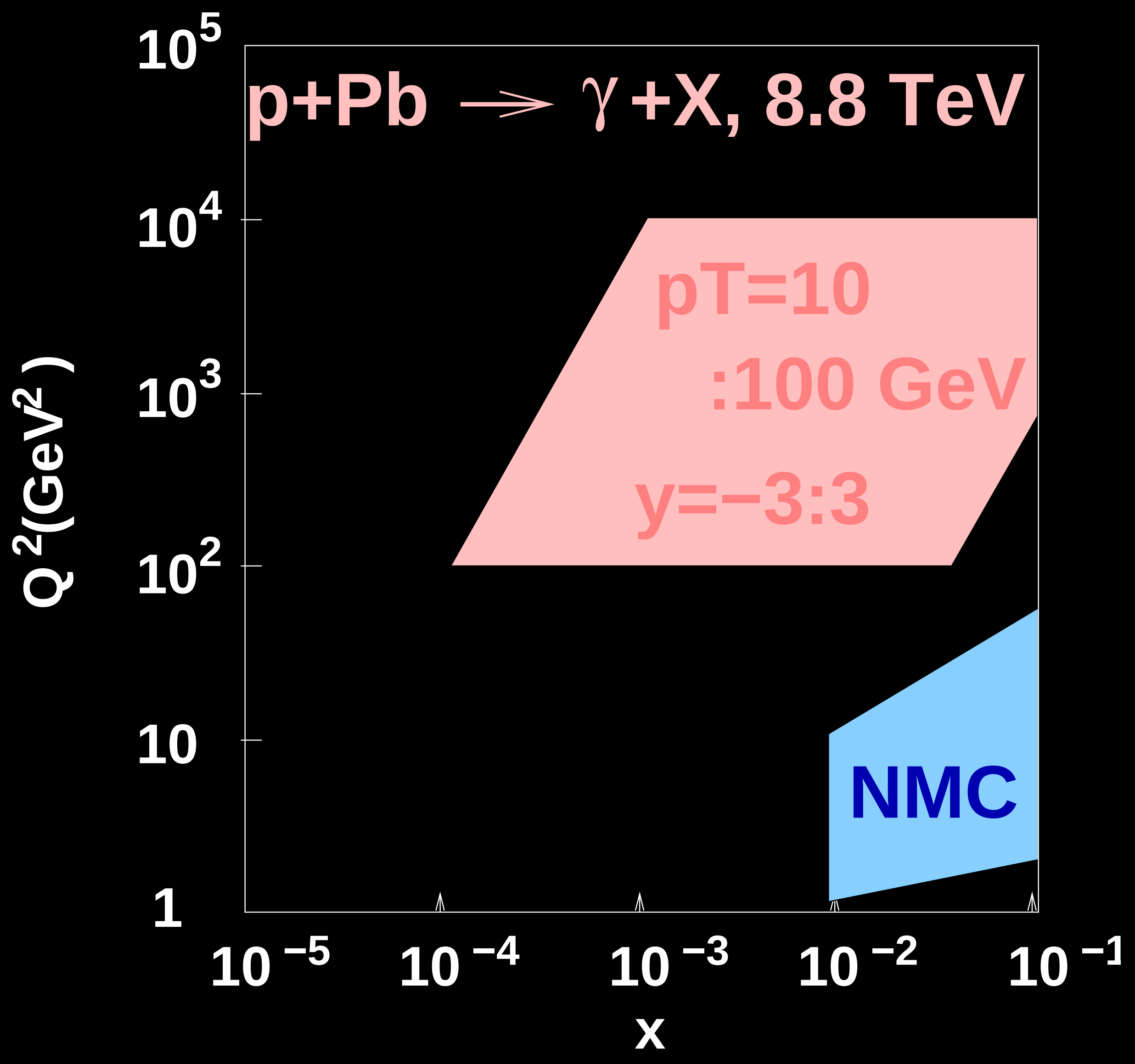

p+Pb → γ +X, 8.8 TeV
pT=10
:100 GeV
y=−3:3
NMC
Q^2(GeV^2)
x
10^5
10^4
10^3
10^2
10
1
10^{-5}
10^{-4}
10^{-3}
10^{-2}
10^{-1}

Prompt photon production at large p_T

$$d\sigma(p + p \to \gamma + X) \overset{\text{LO}}{=} u_1 * \bar{u}_2 * d\hat{\sigma}(u + \bar{u} \to \gamma + g) +$$
$$u_1 * G_2 * d\hat{\sigma}(u + g \to \gamma + u) + \cdots +$$
$$u_1 * G_2 * d\hat{\sigma}(u + g \to u + g) * D_u^{\gamma} + \cdots$$

Prompt photon production at large p_T

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direct

fragmentation

Rich phenomenology

$$\frac{d^3\sigma}{dy d^2 p_T}(p + p \to \gamma + X) \text{ vs } s,\ p_T,\ y$$

- measured at several energies
- with various projectiles
- collider data well described by pQCD at NLO

Nuclear ratios

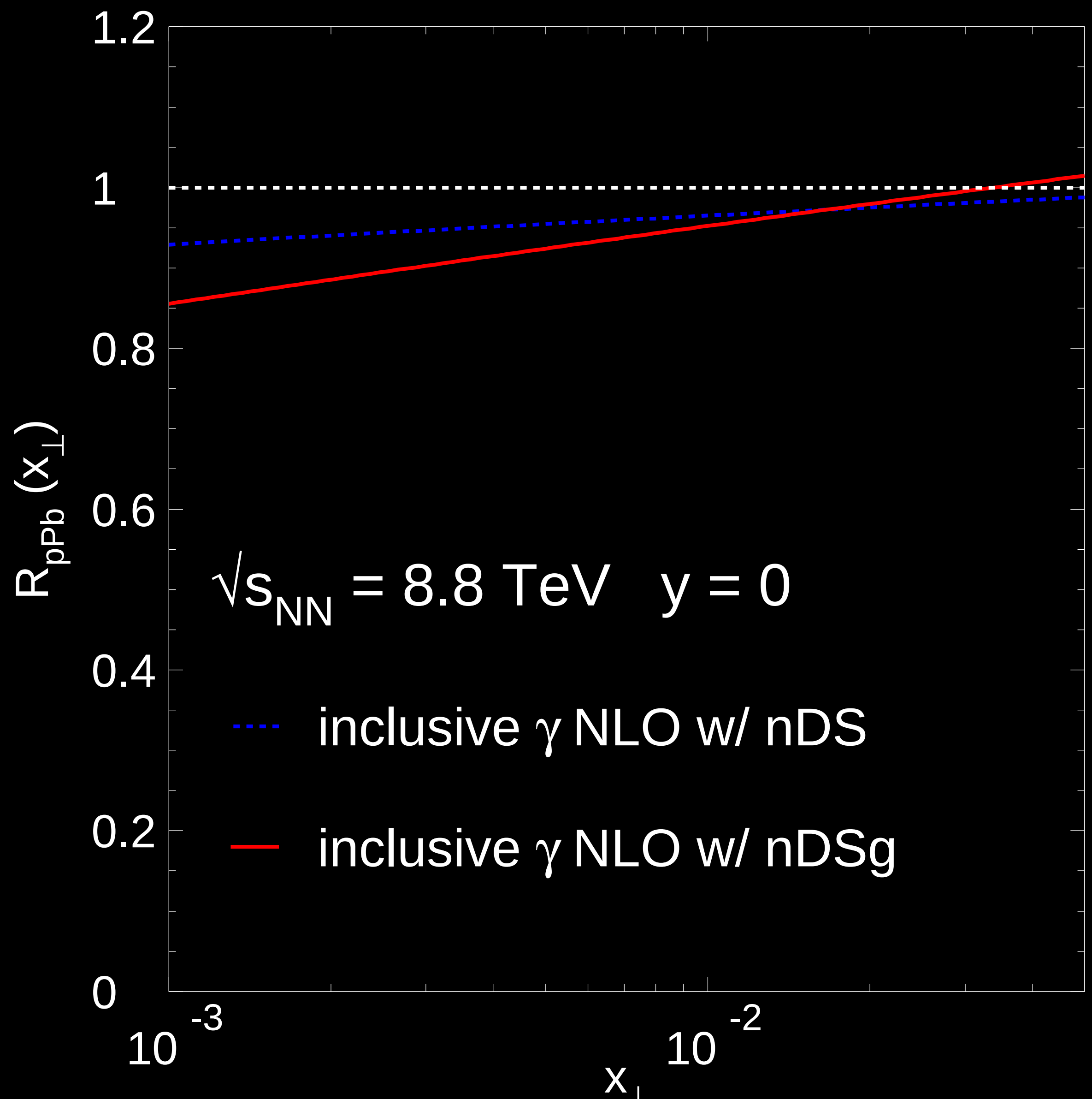
$$R_{pA} = \frac{d\sigma(p + A \to \gamma + X)}{A\, d\sigma(p + p \to \gamma + X)} \text{ vs } x_T,\ y,\ s$$

- studied with INCNLO

[Aurenche *et al*, Eur Phys J 9, 107 (1999)]

- putting either f_p or f_A
- $\sqrt{s} = 8.8$ TeV, $x_T = p_T/(\sqrt{s}/2)$

Inclusive photons at $y = 0$



Rates

$\longrightarrow$ Sensitive to modification of parton densities...

$\longrightarrow$ ...and to change of isospin composition

One month at $\mathcal{L} = 10^{29}$ cm^2/s

10^6 photons per GeV at $p_T = 10$ GeV

in $\Delta y \times \Delta\phi = 1 \times 2\pi$

Isolated photons

- Cut out the π^0 background...
- ...and the fragmentation component
- Nuclear ratio computed with JETPHOX

[Aurenche *et al*, Phys Rev D 73, 094007 (2006)]

- with isolation criterion: $E_T^{\rm had}/p_T^\gamma \leq 0.1$ in a cone of radius $R = 0.4$ around the photon

Direct extraction of f_A/f_p

- in $d\sigma = f_1 * f_2 * d\hat{\sigma}$ the x region is selected by the behavior of the parton densities
- ratios such as $R_G = G_A/G_p$ show much less variation

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$\longrightarrow$ factorize them out of the convolution

Which x?

At LO, the Compton cross section is

$$\frac{d^3\sigma}{dy d^2 p_T} \propto \int dv\ F^{(1)}\left(\frac{x_T e^{y}}{2v}\right) G^{(2)}\left(\frac{x_T e^{-y}}{2(1-v)}\right)\left(1 - v + \frac{1}{1-v}\right)$$
$$+ G^{(1)}\left(\frac{x_T e^{y}}{2v}\right) F^{(2)}\left(\frac{x_T e^{-y}}{2(1-v)}\right)\left(v + \frac{1}{v}\right),$$

At small x_T (and not-too-large $|y|$)

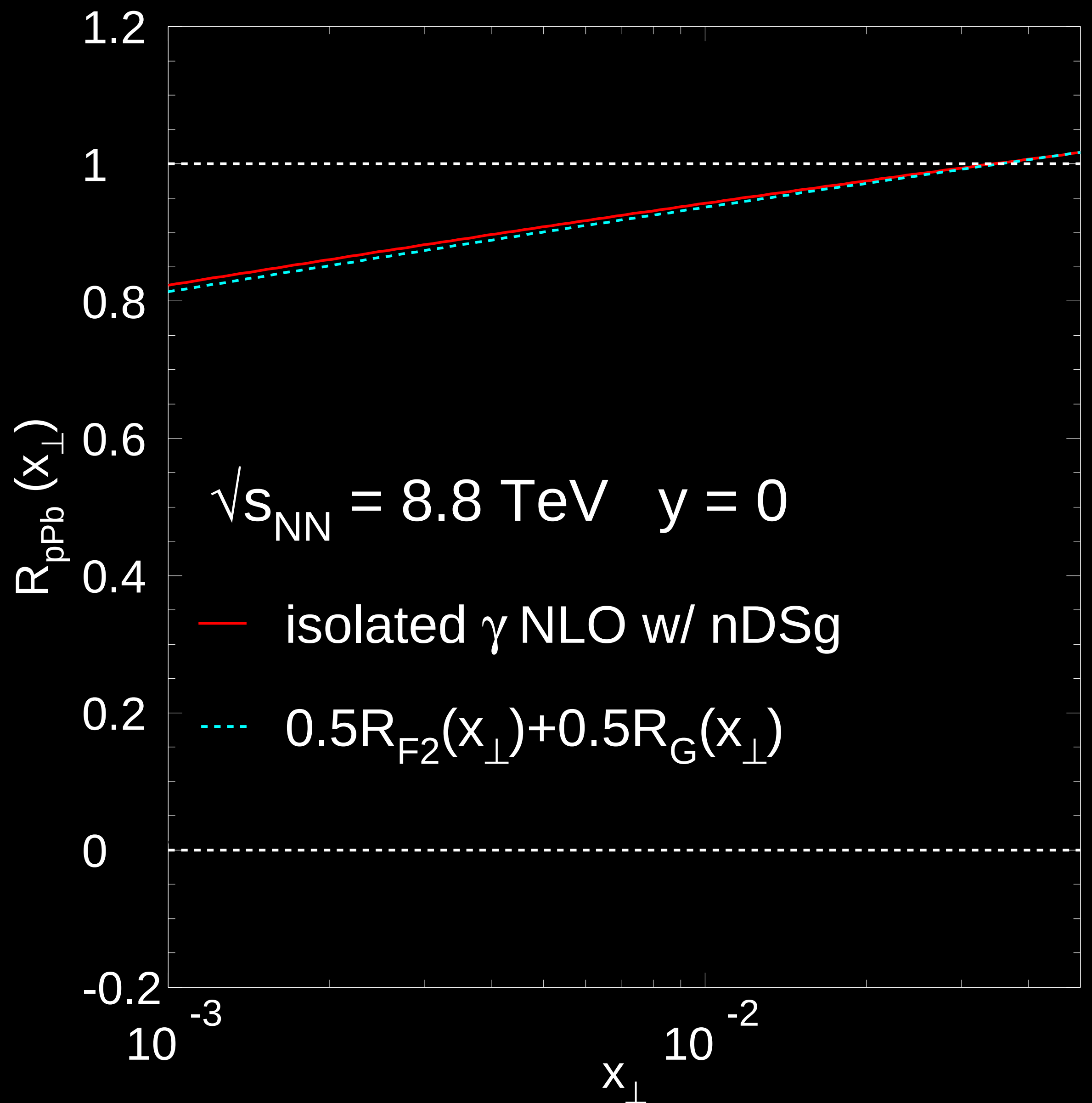
- $F(x) \sim A x^{-a}$ and $G(x) \sim B x^{-b} \to F \times G \propto v^a (1-v)^b$

$\rightarrow \quad R \rightarrow R(x_T e^{-y})$

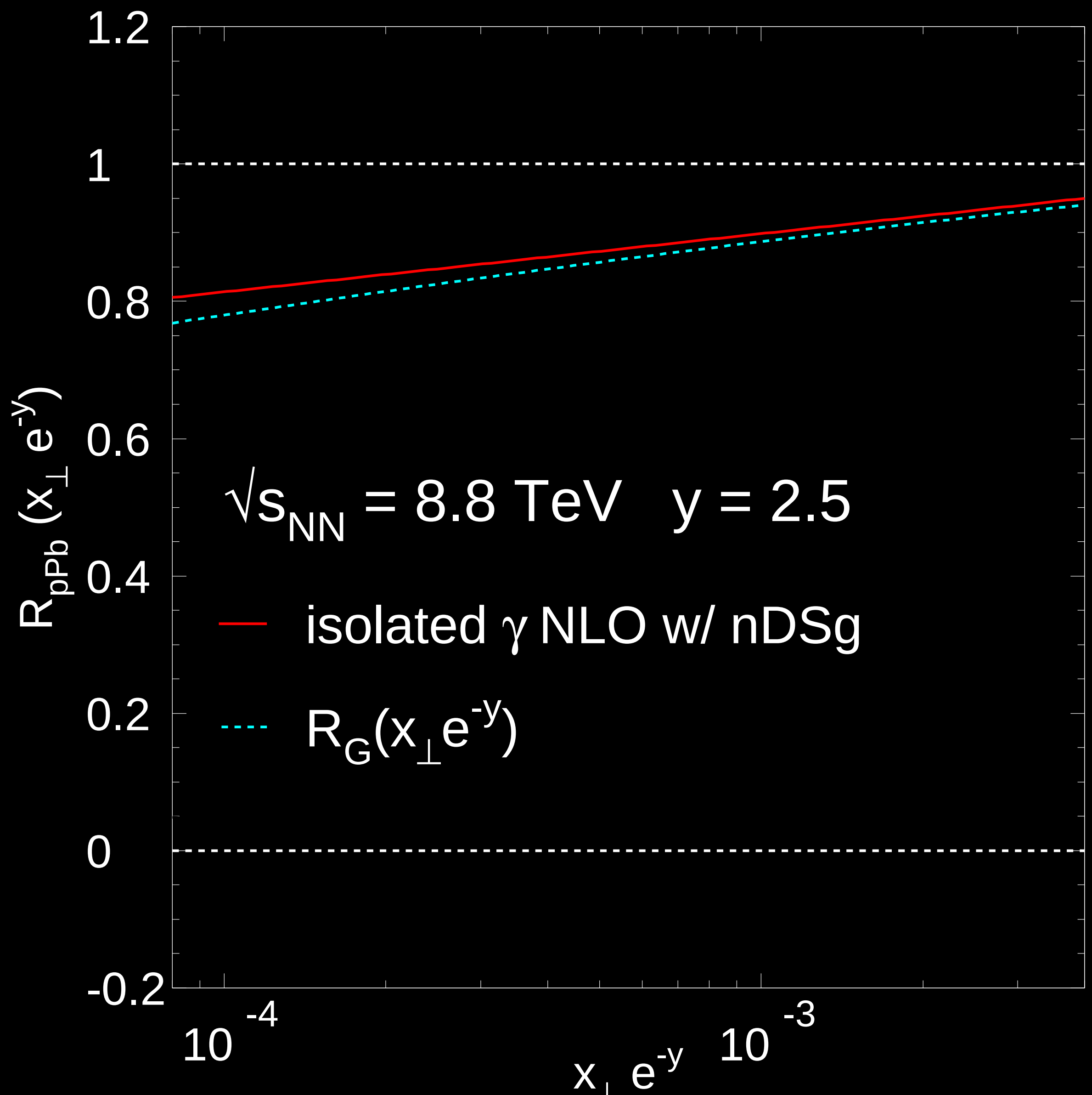
Approximate behavior

- At $y = 0$, the nuclear ratio is $\approx 0.5(R_G + R_{F_2})$
- at $y = 2.5$, it is $\approx R_G$

Isolated photons at $y = 0$



Isolated photons at $y = 2.5$



- Nuclear modifications up to 20%

$\Rightarrow$ **challenging measurements**

- same energy for pp and pA or effect of extrapolation
- photon channel to be compared with
  - ◇ jet production
  - ◇ low-mass dilepton
  - ◇ open charm and beauty